Societal Vulnerability and Climate

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Policy debate and advocacy on the issue of climate change frequently focus on the potential future impacts of climate on society, usually expressed as economic damage or other human outcomes. This essay emphasizes that societal impacts of climate are a joint result of climate phenomena (e.g., hurricanes, floods, and other extremes) *and* societal vulnerability to those phenomena. The essay concludes that policies focused on reducing societal vulnerability to the impacts of climate have important and under-appreciated dimensions that are independent of energy policy.

Figure 1

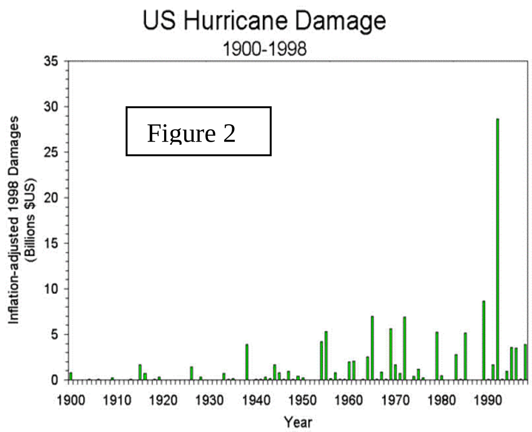
In the climate change debate, people often point to possible increases in extreme weather events (e.g., hurricanes, floods, and winter storms) as a potentially serious consequence of climate change for humans around the world (Figure 1). This essay uses the case of hurricanes to illustrate the interrelated climate-society dimensions of climate impacts. Research indicates that societal vulnerability is the single most important factor in the growing damage related to extreme events. An implication of this research for policy is that decision making at local levels (such as related to land use, insurance, building codes, warning and evacuation, etc.) can have a profound effect on the magnitude and significance of future damage.[1]

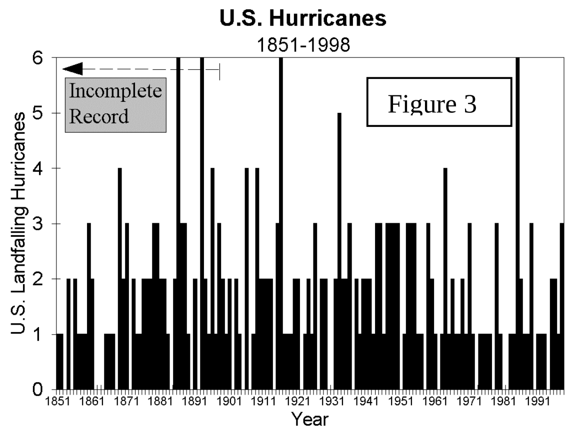
Figure 2 shows economic damage (adjusted for inflation) related to hurricane landfalls in the United States, 1900-1998.[2] Because damage is growing in both frequency and intensity, one possible interpretation of this figure is that hurricanes have become more frequent and possibly stronger in recent decades. However, while hurricane

[1] For an in depth presentation of this perspective, see Sarewitz, D., R. A. Pielke, Jr., 2000: Breaking the Global-Warming Gridlock. The Atlantic Monthly, July:55-64, online at http://www.theatlantic.com/cgi-bin/o/issues/2000/07/sarewitz.htm

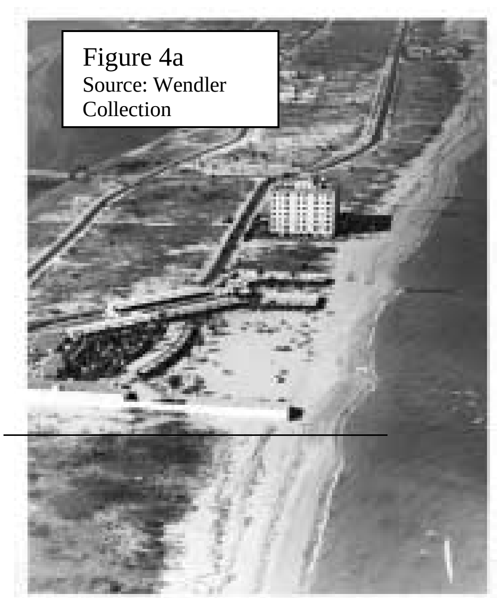
[2] For discussion, see Pielke, Jr., R. A., and C. W. Landsea, 1998: Normalized Hurricane Damages in the United States: 1925-1995. Weather and Forecasting, 13, 351-361, online at http://www.esig.ucar.edu/HP_roger/pdf/wf13.pdf

frequencies have varied a great deal over the past 100+ years, they have not increased in recent decades (Figure 3, provided courtesy of C. Landsea, NOAA).[3] To the contrary, although damage increased during the 1970s and 1980s, hurricane activity was considerably lower than in previous decades.





To explain the increase in damage it is necessary to consider factors other than climate. In particular, society has changed enormously during the period covered by Figure 2. Figures 4a and b show this dramatically. Figure 4a shows a stretch of Miami Beach in 1926. Figure 4b shows another perspective of Miami Beach from recent years. The reason for increasing damages is apparent from the changes easily observable in



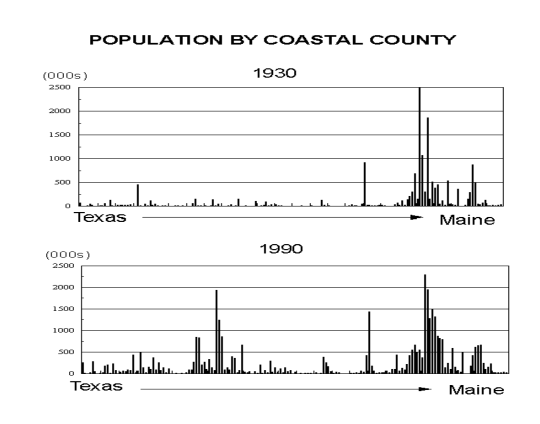
[3] See Landsea, C. L., R. A. Pielke, Jr., A. Mestas-Nuñez, and J. Knaff, 1999: Atlantic Basin Hurricanes: Indicies of Climate Changes. Climate Change, 42, 89-129, online at http://www.aoml.noaa.gov/hrd/Landsea/atlantic/index.html
See also Landsea, C. W., C. Anderson, N. Charles, G. Clark, J. Partagas, P. Hungerford, C. Neumann and M. Zimmer, 2001: The Atlantic Hurricane Database Re-analysis Project: Documentation for the 1851-1885 Addition to the HURDAT Database. Chapter for the Risk Prediction Initiative book, R. Murnane and K. Liu, Editors. Online: http://www.aoml.noaa.gov/hrd/hurdat/index.html

these figures: today there is more potential for economic damage than in the past due to population growth and increased wealth (e.g., personal property).

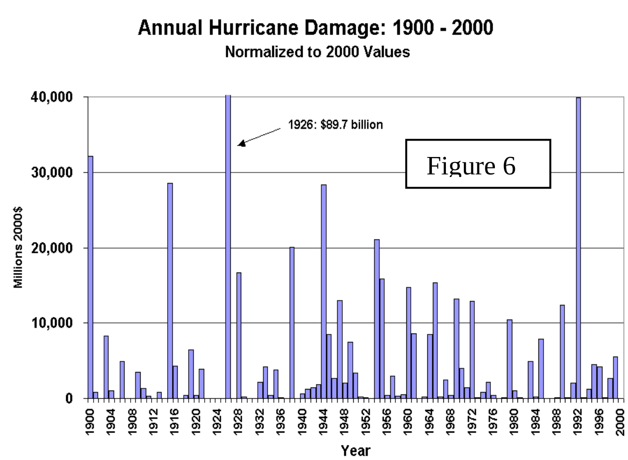
Figure 5b shows the increase in population along the Gulf and Atlantic coasts for 168 coastal counties from Texas through Maine (Figure 5a). In 1990, the population of Miami and Ft. Lauderdale (2 counties) exceeded the combined population of 107 counties from Texas to Virginia.[4] Clearly, societal changes such as coastal population growth have had a profound effect on the frequency and magnitude of impacts from weather events such as hurricanes.[5]

Figure 5a

Figure 5b



One way to present a more accurate perspective on trends in hurricane-related impacts is to consider how past storms would affect present society. A 1998 paper presented a methodology for "normalizing" past hurricane damage to present day values (using wealth, population and inflation). Figure 6 shows the historical losses of Figure 2 normalized to 2000 values.[6]



[4] Pielke, Jr., R. A., and R. A. Pielke, Sr., 1997: Hurricanes: Their Nature and Impacts on Society. John Wiley and Sons Press: London.
[5] For a review, see Kunkel, K., R. A. Pielke Jr., S. A. Changnon, 1999: Temporal Fluctuations in Weather and Climate Extremes That Cause Economic and Human Health Impacts: A Review. Bulletin of the American Meteorological Society, 80, 6, 1077-1098, online at http://www.esig.ucar.edu/HP_roger/pdf/bams8006.pdf
[6] After Pielke and Landsea (1998), op. cit.

The normalized record shows that the impacts of Hurricane Andrew, at close to $40 billion (2000 values), would have been far surpassed by the Great Miami Hurricane of 1926, which would cause an estimated $90 billion damage had it occurred in 2000. We can have confidence that the normalized loss record has done a good job accounting for societal changes because the data contains climatological information, such as the signal of El Niño and La Niña.[7]

The normalization methodology provides an opportunity to perform a sensitivity analysis of the relative contributions of climate changes and societal changes, as projected by the Intergovernmental Panel on Climate Change (IPCC), to future topical cyclone damages. Figure 7 shows the results of this analysis.[8] The three blue bars show three different calculations (named for their respective authors) used by IPCC in its Second Assessment Report for the increase in tropical cyclone-related damage in 2050 (relative to 2000) resulting from changes in the climate, independent of any changes in society. The four green bars show the sensitivity of tropical cyclone-related damage in 2050 (relative to 2000) resulting from changes in society based on four different IPCC population and wealth scenarios used in its Third Assessment Report. These changes are independent of any changes in climate.

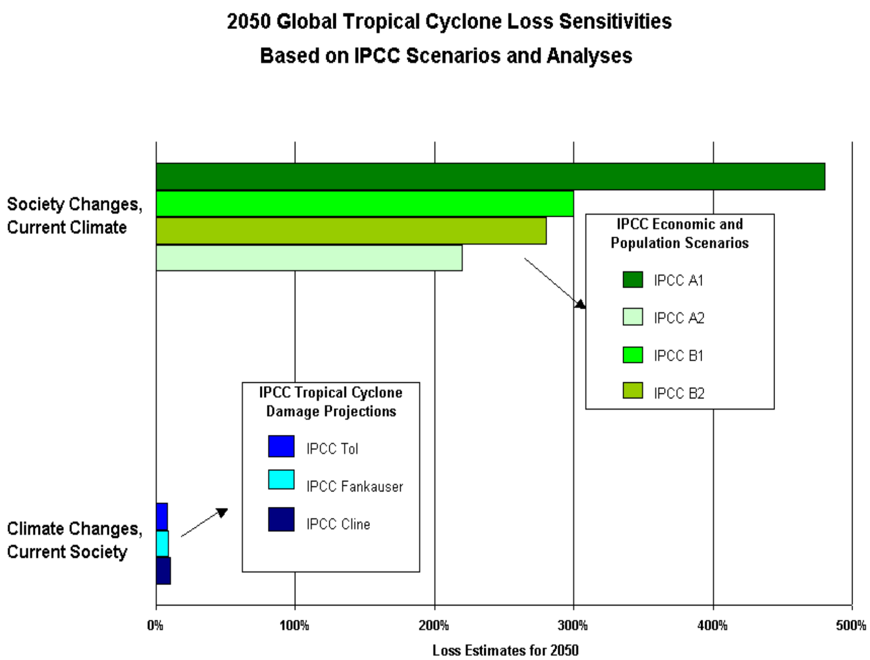


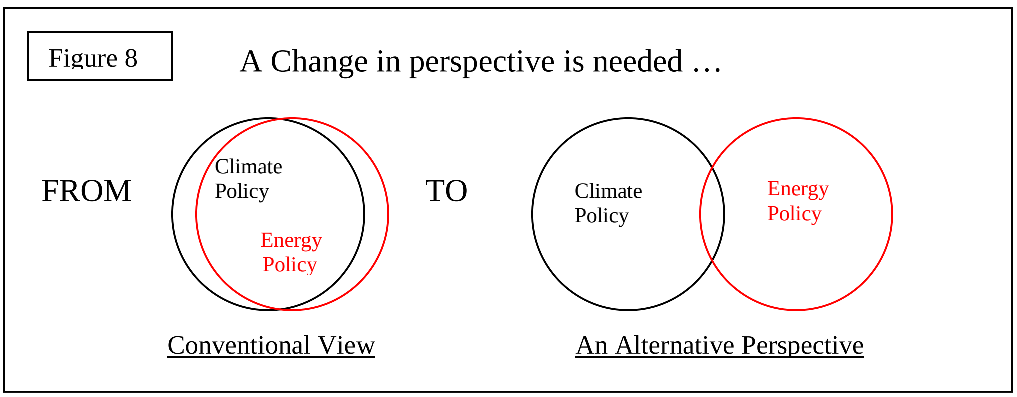
Figure 7

[7] Pielke, Jr., R.A., and C.W. Landsea, 1999: La Niña, El Niño, and Atlantic Hurricane Damages in the United States. Bulletin of the American Meteorological Society, 80, 10, 2027-2033, online at http://www.esig.ucar.edu/HP_roger/pdf/bams8010.pdf

[8] Details on this sensitivity analysis can be found in Pielke, Jr., R. A., R. Klein, and D. Sarewitz, 2000: "Turning the Big Knob: An Evaluation of the Use of Energy Policy to Modulate Future Climate Impacts." Energy and Environment, 11, 255-276, online at http://www.esig.ucar.edu/knob/index.html

Figure 7 illustrates dramatically the profound sensitivity of future climate impacts to societal change, even in the context of climate changes projected by the IPCC. The relative sensitivity of societal change to climate change ranges from 22 to 1 (i.e., smallest societal sensitivity and largest climate sensitivity) to 60 to 1 (i.e., largest societal sensitivity and smallest climate sensitivity). This indicates that insofar as tropical cyclones are concerned, steps taken to modulate the future climate (e.g., via greenhouse gas emissions or other energy policies) would only address a very small portion of the increasing damages caused by tropical cyclones. Similar results have been found for tropical cyclone impacts in developing countries,[9] flooding,[10] other extremes,[11] and water resources.[12]

An implication of this work is that policy related to societal impacts of climate has important and under-appreciated dimensions that are independent of energy policy. It would be a misinterpretation of this work to imply that it supports either business-as-usual energy policies, or is contrary to climate mitigation. It does suggest that if a policy goal is to reduce the future impacts of climate on society, then energy policies are insufficient, and perhaps largely irrelevant, to achieving that goal. Of course, this does not preclude other sensible reasons for energy policy action related to climate (such as ecological impacts) and energy policy action independent of climate change (such as air pollution reduction and energy efficiency).[13] It only suggests that reduction of human impacts related to weather and climate are not among those reasons, and arguments and advocacy to the contrary are not in concert with research in this area.



[9] Pielke, Jr., R. A., J. Rubiera, C. Landsea, M. Molina, and R. Klein, 2001: Hurricane Vulnerability in Latin America and the Caribbean, Global Environmental Change, Part B: Natural Hazards, (in review).

[10] Pielke, Jr., R.A., and M.W. Downton, 2000: Precipitation and damaging floods: Trends in the United States, 1932-1997. Journal of Climate, 13(20), 3625-3637, online at http://www.esig.ucar.edu/HP_roger/pdf/jc1320.pdf

[11] See Kunkel et al. 1999, op. cit.

[12] C. J. Vörösmarty, P. Green, J. Salisbury, and R. B. Lammers, 2000. Global Water Resources: Vulnerability from Climate Change and Population Growth, *Science* **289**: 284-288. D.P. Lettenmaier, A.W. Wood, R.N. Palmer, E.F. Wood, and E.Z. Stakhiv, 1999, Water Resources Implications of Global Warming: A U.S. Regional Perspective, *Climatic Change*, **43**:537-579.

[13] See, e.g., F. Laird 2001, Just say no to emissions reductions targets, *Issues in Science and Technology*, Winter, online: http://www.nap.edu/issues/17.2/laird.htm R. Brunner 2001. Science and the Climate Change Regime, *Policy Sciences* 34:1-33.

This work suggests a need to distinguish "climate policy" from "energy policy" (Figure 8). "Climate policy" refers to the actions that organizations and individuals take to reduce their vulnerability to (or enhance opportunities afforded by) climate variability and change.[14] From this perspective governments and businesses are already heavily invested in climate policy. In the context of hurricanes and floods, climate policies might focus on land use, insurance, engineering, warnings and forecasts, risk assessments, and so on. These are the policies that will make the most difference in reducing the future impacts of climate on society.

The conventional view is that climate policy *is* energy policy. However, much of the debate and discussion on climate change revolves around energy policy and ignores the fact that such policies, irrespective of their merit, can do little to address growing societal vulnerabilities to climate around the world. In all contexts, improving policies targeted on the societal impacts of climate depends on a wide range of factors other than energy policy. Consequently, in light of the analyses presented in this essay, a common interest objective of climate policy would be to improve societal and environmental resilience to climate variability and change, and to reduce the level of vulnerability. Climate policy should be viewed as a complement, not an alternative, to energy policies.

[14] Note that here I use the broad definition of "climate change" used by the IPCC: "… related to any source" rather than the more restricted definition of the FCCC which defines climate change only in terms of those changes directly or indirectly attributable "to human activity that alters the composition of the global atmosphere …" For discussion, see Pielke, Jr., R. A., 1998: Rethinking the role of adaptation in climate policy. *Global Environmental Change*, 8(2), 159-170.

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Roger A. Pielke, Jr. is a Scientist III at the Environmental and Societal Impacts Group at the National Center for Atmospheric Research in Boulder, Colorado. With a B.A. in mathematics and a Ph.D. in political science from the University of Colorado, he focuses his research on the relation of scientific information and public and private sector decision making. His current areas of research are societal responses to extreme weather events, domestic and international policy responses to climate change, and United States science policy. In 2000, he received the Sigma Xi Distinguished Lectureship Award. He currently chairs the American Meteorological Society=s Committee on Societal Impacts, and serves on the Science Steering Committee of the World Meteorological Organization's World Weather Research Programme and the National Academy of Sciences Board on Atmospheric Sciences and Climate, among other scientific and advisory committees. He has authored more than 70 papers, chapters, and articles and is a co-author or co-editor of three books, most recently (with D. Sarewitz and R. Byerly) ***Prediction: Decision making and the future of nature*** (2000, Island Press).